FORM PTO-1390 U S DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY'S DOCKET NUMBER	
50212-211	
U.S. APPLIC. NO. (if known, see 37 CFR 1.5)	
09/807902	

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/JP99/05753	October 19, 1999	October 19, 1998

TITLE OF INVENTION

WAFER SUPPORT IN SEMICONDUCTOR PRODUCTION APPARATUS

APPLICANT(S) FOR DO/EO/US

Kenichi ARIMURA, Seiji ARIMA, and Yoji TAKAGI

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371
3. ☒ This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).
4. ☒ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. ☐ is transmitted herewith (required only if not transmitted by the International Bureau).
   b ☒ has been transmitted by the International Bureau.
   c ☐ is not required, as the application was filed in the United States Receiving Office (RO/US)
6. ☒ A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. ☐ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
   b ☐ have been transmitted by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendment has NOT expired.
   d. ☐ have not been made and will not be made
8. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S C 371(c)(3))
9. ☒ An oath or declaration of the inventor(s) (35 U.S C. 371(c)(4)).
10. ☐ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U S C. 371(c)(5)).

Items 11. to 16. below concern other document(s) or information included:

11. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☒ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☒ A FIRST preliminary amendment.
    ☐ A SECOND or SUBSEQUENT preliminary amendment
14. ☐ A substitute specification.
15. ☐ A change of power of attorney and/or address letter
16. ☒ Other items or information.

Associate Power of Attorney
International Search Report prepared by JPO

20277

PATENT TRADEMARK OFFICE

U.S. APPLIC. NO. (if known, see 37 CFR 1.50)	INTERNATIONAL APPLICATION NO.	ATTORNEY'S DOCKET NUMBER
09/807902	PCT/JP99/05753	50212-211

	CALCULATIONS	PTO USE ONLY
17. ☒ The following fees are submitted:		
Basic National Fee (37 CFR 1.492(a)(1)-(5)): Search Report has been prepared by the EPO or JPO $860.00		
International preliminary examination fee paid to USPTO (37 CFR 1.482) $690.00		
No international preliminary examination fee paid to USPTO (37 CFR 1.482) but international search fee paid to USPTO (37 CFR 1.445(a)(2)) $710.00		
Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO $1,000.00		
International preliminary examination fee paid to USPTO (37 CFR 1 482) and all claims satisfied provisions of PCT Article 33(2)-(4) $100.00		
ENTER APPROPRIATE BASIC FEE AMOUNT =	$ 860.00	
Surcharge of $130.00 for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(e))	$	

Claims	Number Filed	Number Extra	Rate		
Total Claims	11 -20 =	0	x $18.00	$	
Independent Claims	1 -3 =	0	x $80.00	$	
Multiple dependent claim(s) (if applicable)			+ $270.00	$	
			TOTAL OF ABOVE CALCULATIONS =	$ 860.00	
Reduction by 1/2 for filing by small entity, if applicable. Verified Small Entity Statement must also be filed. (Note 37 CFR 1.9, 1.27, 1 28).				$	
			SUBTOTAL =	$ 860 00	
Processing fee of $130 00 for furnishing the English translation later than the ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(f)). +				$	
			TOTAL NATIONAL FEE =	$ 860.00	
Fee for recording the enclosed assignment (37 CFR 1 21(h)) The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31) $40.00 per property +				$ 40 00	
			TOTAL FEES ENCLOSED =	$ 900.00	
			Amount to be: refunded	$	
			charged	$	

a. ☐ A check in the amount of $ _____ to cover the above fees is enclosed.

b. ☒ Please charge my Deposit Account No. 500417 in the amount of $ 900.00 to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No 500417 A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

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600 13th Street, N.W.
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(202) 756-8000
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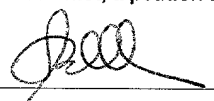

SIGNATURE

Stephen A. Becker
NAME

26,527
REGISTRATION NUMBER

April 19, 2001
DATE

09/807902

JC03 Rec'd PCT/PTO 19 APR 2001

Docket No.: 50212-211

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of	:	
Kenichi ARIMURA, et al.	:	
Serial No.:	:	Group Art Unit:
Filed: April 19, 2001	:	Examiner:

For: WAFER SUPPORT IN SEMICONDUCTOR PRODUCTION APPARATUS

PRELIMINARY AMENDMENT

Commissioner for Patents
Washington, DC 20231

Sir:

Prior to examination of the above-referenced application, please amend the application as follows:

IN THE CLAIMS:

Please amend claim 3 as follows:

3. A semiconductor production apparatus according to claim 1 [or 2], wherein said depression has an elongated form extending in a radial direction of said susceptor.

REMARKS

The above-referenced application is amended to delete the multiple dependency of claim 3 to avoid the multiple dependent claim filing fee.

Appended hereto as Appendix A is a clean copy of claim 3 as amended.

Respectfully submitted,

MCDERMOTT, WILL & EMERY

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APPENDIX A

3. A semiconductor production apparatus according to claim 1, wherein said depression has an elongated form extending in a radial direction of said susceptor.

DESCRIPTION

Wafer Support in Semiconductor Production Apparatus

Technical Field

The present invention relates to a semiconductor production apparatus having a heating source, such as epitaxial growth apparatus and rapid thermal treatment apparatus; and, in particular, to an improvement in a wafer support for supporting a semiconductor wafer.

Background Art

Fig. 1 is a sectional view schematically showing a major-part of an epitaxial growth apparatus 1 which is a conventional semiconductor production apparatus. In Fig. 1, the epitaxial growth apparatus 1 is of a single wafer processing type, which processes semiconductor wafers or silicon wafers W one by one, and comprises a process chamber 2 constituted by silica glass, and a wafer support 3 disposed within the process chamber 2 for supporting a wafer W. The wafer support 3 is constituted by a susceptor 4 having an upper surface for supporting the wafer, and a susceptor support shaft 5 for supporting the susceptor 4. A side portion of the process chamber 2 is formed with an inlet 6 for a process gas, whereas an outlet 7 is formed at a position opposite from the inlet 6. A

plurality of halogen lamps 8 are radially disposed in each of areas above and below the process chamber 2.

Fig. 2 is a schematic perspective view showing the susceptor 4 and susceptor support shaft 5 of the conventional wafer support 3. Fig. 3 is a bottom plan view of the susceptor 4. As shown in these drawings, the susceptor support shaft 5 is constructed by a main shaft 5a, and three arms 5b arranged at equally spaced intervals in the circumferential direction so as to radially extend from the upper end of the main shaft 5a. The distal ends of the main shaft 5a and the arms 5b are provided with circular-rod-like protrusions 5c and 5d for supporting the susceptor 4, respectively. Also, the lower surface of the susceptor 4 is formed with depressions 4a, 4b, 4c located at the positions corresponding to the protrusions 5c and 5d, respectively. Here, since the susceptor 4 is positioned by the depression 4a formed at the center of the susceptor 4 and the protrusion 5c, the inside diameter of the depression 4a and the outside diameter of the protrusion 5c are substantially identical to each other. Among the three depressions formed in the outer peripheral portion of the susceptor 4, the depression indicated by 4b

is shaped into an elongated hole, which has a width identical to the outside diameter of the protrusion 5d for preventing the susceptor 4 from circumferentially moving about the protrusion 5c. The remaining depressions 4c are countersunk holes for simply supporting the susceptor 4, each having an inside diameter greater than the outside diameter of the protrusion 5d.

In the conventional epitaxial growth apparatus 1, which is configured as in the foregoing, a silicon wafer W is initially mounted on the susceptor 4, and then the halogen lamps 8 are lit, so as to heat the silicon wafer W. At the same time, trichlorosilane ($SiHCl_3$) gas, dichlorosilane (SiH_2Cl_2) gas, or the like, for example, is introduced as a process gas from the inlet 6 while being let out from the outlet 7. Then, the process gas flows in the state of a laminar flow along the surface of the silicon wafer W heated to a predetermined temperature, whereby a single crystal of silicon epitaxially grows on the silicon wafer W.

When a silicon film is formed by use of the conventional epitaxial growth apparatus 1 such as that mentioned above, however, the thickness of silicon film may abruptly drop in the vicinity of the center of silicon wafer W, thus failing to yield

a silicon film having a uniform thickness.

Therefore, it is a main object of the present invention to provide an improved semiconductor production apparatus which can yield a film having a uniform thickness, without using additional apparatus.

Disclosure of the Invention

The inventors have carried out various studies in order to achieve the above-mentioned object and, as a result, have reached a conclusion that the protrusion located under the center of susceptor inhibits the radiant heat from the halogen lamps under the process chamber.

Therefore, the present invention provides a semiconductor production apparatus including a process chamber; a wafer support disposed within the process chamber for supporting a semiconductor wafer; and a heating source, such as halogen lamp, for heat treatment of the semiconductor wafer supported by the wafer support; wherein the wafer support comprises a susceptor having an upper surface for mounting the semiconductor wafer thereon, and a susceptor support shaft for supporting the susceptor from thereunder; wherein the susceptor support shaft having a main shaft positioned substantially coaxial with the center of the

susceptor, and at least three arms radially extending from an upper end of the main shaft, each arm having a distal end provided with a protrusion directed toward the susceptor; and wherein a peripheral portion of a lower surface of the susceptor being formed with depressions, each depression having an inside diameter substantially identical to an outside diameter of the protrusion, adapted to engage the protrusion.

According to the present invention, the susceptor has a structure in which it is supported by only the arms extending in its peripheral portion, whereas the protruded part of the susceptor support shaft is not disposed at the lower surface of the center portion of the susceptor, thereby being kept from affecting the heat conduction to the center portion of the susceptor. In particular, the radiant heat from the heating source disposed under the process chamber is not inhibited at the center portion of the susceptor. Therefore, the susceptor and semiconductor wafer, as a whole, are uniformly heated, and a film can be grown with a uniform thickness over the whole surface of the semiconductor wafer. Also, since the positioning is effected by at least three points by the depressions formed at the peripheral portion of the

lower surface of the susceptor and the protrusions at the arm ends of the susceptor support shaft, more accurate positioning can be carried out.

Preferably, each depression has an elongated form radially extending in a radial direction of the susceptor. As a consequence, it can absorb the difference in coefficient of thermal expansion between the susceptor and the susceptor support shaft. When the coefficient of thermal expansion of the susceptor is greater than that of the susceptor support shaft in this case, it is preferred that the protrusions engage their corresponding depressions on the outermost peripheral side thereof at ambient temperature.

Preferred as the susceptor is one comprising carbon graphite or silicon carbide. The susceptor may also have a configuration comprising a carbon graphite base and a silicon carbide coating covering a surface of the base. Preferred as the susceptor support shaft is one comprising silica glass.

In the case where the process chamber is provided with an inlet for a process gas and an outlet for letting out the gas from the process chamber, a film can be formed on a surface of a semiconductor wafer by epitaxial growth if the process gas for carrying out an epitaxial growth process is supplied

into the process chamber from the inlet.

Preferably, the arms of the susceptor support shaft incline upward as they extend radially outward.

The above-mentioned and other characteristics features and advantages of the present invention will be clear to one skilled in the art by reading the following detailed explanations with reference to the accompanying drawings.

Brief Description of the Drawings

Fig. 1 is a sectional view schematically showing a conventional semiconductor production apparatus;

Fig. 2 is a schematic perspective view showing a conventional wafer support in a dissembled state;

Fig. 3 is a bottom plan view of a conventional susceptor;

Fig. 4 is a sectional view schematically showing a semiconductor production apparatus in accordance with the present invention;

Fig. 5 is a schematic perspective view showing the wafer support in Fig. 4 in a dissembled state;

Fig. 6 is a bottom plan view showing the susceptor of Figs. 4 and 5;

Fig. 7 is a sectional view taken along the line A-A of Fig. 6; and

Fig. 8 is a graph showing the relationship between the distance from the center of a silicon wafer W and the thickness of silicon film.

Best Modes for Carrying Out the Invention

In the following, a preferred embodiment of the present invention will be explained in detail with reference to the drawings.

Fig. 4 is a sectional view schematically showing a major-part of an epitaxial growth apparatus 10 in accordance with the present invention. The shown epitaxial growth apparatus 10 is of a single wafer processing type, which processes semiconductor wafers or silicon wafers W one by one, and comprises a process chamber 12 constituted by silica glass, for example, and a wafer support 14 disposed within the process chamber 12 for supporting a wafer W. A side portion of the process chamber 12 is formed with an inlet 16 for a process gas for carrying out epitaxial growth. A process gas source, which is not shown, is connected to the inlet 16. Also, a side portion of the process chamber 12 is formed with an outlet 18 at a position opposite from the inlet 16. A plurality of halogen lamps 20 are radially disposed with an appropriate arrangement in each of areas above and below the process chamber 12.

As schematically shown in Fig. 5, the wafer support 14 comprises a flat disk-shaped support plate or susceptor 22. Preferably, the susceptor 22 is formed from carbon graphite. As a matter of course, the susceptor 22 may be made solely of other materials such as silicon carbide, for example, or may be formed from carbon graphite having a surface coated with silicon carbide. The upper surface of the susceptor 22 is formed with an area for resting and supporting the silicon wafer W thereon.

The wafer support 14 comprises a susceptor support shaft 24 for horizontally supporting the susceptor 22. The susceptor support shaft 24 has a main shaft 26, disposed coaxial with the process chamber 12, vertically extending into the process chamber 12 from thereunder. An upper end of the main shaft 26 is integrally formed with three arms 28 radially extending outward. The arms 28 have the same form and are disposed at equally spaced intervals in the circumferential direction. Preferably, each arm 28 inclines upward as it extends outward. The distal end of each arm 28 is integrally formed with a protrusion 30 for resting and supporting the susceptor 22 thereon. Though the shown protrusion 30 is shaped like a circular cylinder as a whole and vertically extends upward,

it will be sufficient if at least the upper end portion of the protrusion is shaped like a vertically extending circular cylinder. Preferably, such a susceptor support shaft 24 is integrally formed from silica glass.

The susceptor 22 can be mounted and supported by the distal end of the above-mentioned protrusion 30. In this supporting state, the susceptor 22 should be disposed concentric with the main shaft 26. Therefore, as shown in Figs. 5 and 6, a depression 32 is formed in the lower surface of the susceptor 22 at the position where the upper end of each protrusion 30 abuts in order to receive the protrusion 30 and limit the movement of the susceptor 22 relative to the susceptor support shaft 24. Though it is not particularly necessary to specify the depth of the depression 32 since it will be sufficient if the depression 32 can limit the horizontal movement of the susceptor 22, the depth is preferably about half the thickness of the susceptor 22 as shown in Fig. 7 in order to securely prevent the protrusion from separating out of the depression 32.

Since the positioning of the susceptor 22 with respect to the susceptor support shaft 24 is effected by the depressions 32 formed at the peripheral

portion of the lower surface of the susceptor 22 and the protrusions 30 as mentioned above, it will be sufficient if the inside diameter of depression 32 and the outside diameter of the leading end portion of protrusion 30 are substantially identical to each other. However, if the depression 32 has a circular cross-sectional form identical to that of the protrusion 30, then there is a fear of a mechanical load being applied to the susceptor 22 and/or the susceptor support shaft 24 when the coefficient of thermal expansion greatly differs between the susceptor 22 and the susceptor support shaft 24. Therefore, for absorbing the difference in coefficient of thermal expansion between the susceptor 22 and the susceptor support shaft 24, it is desirable that the depression 32 is formed as an elongated groove extending in the radial direction of the susceptor 22. While the width of the groove 32 is substantially identical to the diameter of the protrusion 30 in order to prevent the susceptor 22 from circumferentially moving, the groove 32 and the protrusion 30 are required to have such dimensions that, when heat is applied thereto, the protrusion 30 can slide within the groove 32 in the radial direction, i.e., in the longitudinal direction of the groove 32. In addition, when the

susceptor support shaft 24 is made of silica glass while the susceptor 22 is made of carbon graphite having a coefficient of thermal expansion greater than that of silica glass, for example, it is desirable that the protrusion 30 is positioned on the outermost peripheral side of the depression 32 as shown in Fig. 6 at ambient temperature. With this arrangement, since the susceptor 22 is supported and positioned by the three protrusions 30 of the susceptor support shaft 24, more accurate positioning can be obtained.

When forming a silicon film by use of thus configured epitaxial growth apparatus 10, a silicon wafer W is initially mounted on a predetermined area on the susceptor 22. Thereafter, the halogen lamps 20 are lit to heat the silicon wafer W. At the same time, trichlorosilane ($SiHCl_3$) gas, dichlorosilane (SiH_2Cl_2) gas, or the like, for example, is introduced as a process gas from the inlet 16 while being let out from the outlet 18. Then, the process gas flows in the state of a laminar flow along the surface of the silicon wafer W heated to a predetermined temperature, whereby a single crystal of silicon epitaxially grows on the silicon wafer W.

When the conventional wafer support shown in Figs. 1 to 3 is used, it is expected that the radiant

heat from the halogen lamps disposed under the process chamber is inhibited by the center protrusion 5c, whereby the temperature at the center portion of the susceptor 22 will be lower than that at the other portions. On the contrary, since the wafer support 14 in accordance with the present invention has no protrusion for supporting the center of the susceptor 22, the radiant heat from the halogen lamps 20 is securely transmitted to the center portion of the susceptor 22 as well. Therefore, the susceptor 22 and the silicon wafer W as a whole are uniformly heated, whereby a silicon film having a uniform thickness is formed over the whole surface of the wafer W.

Upon heating, the susceptor 22 and the susceptor support shaft 24 expand at respective ratios different from each other. Namely, the susceptor 22 made of carbon graphite expands greater than the susceptor support shaft 24 made of silica glass does. However, since each depression 32 shaped like an elongated groove extends in the radial direction of the susceptor 22 while the three depressions are disposed at equally spaced intervals in the circumferential direction, only the protrusion relatively moves toward the center within the depression 32 even when there is a difference

of expansion between the susceptor 22 and the shaft 24, whereby the center point of the susceptor 22 is kept on the center axis of the main shaft 26.

Fig. 8 is a graph showing, in the case where a 200-mm silicon wafer W is used for forming a silicon film upon epitaxial growth by way of example, the relationship between the distance from the center point of silicon wafer W and the thickness of silicon film. Curve A indicates the results obtained when the wafer support in accordance with the present invention was used, whereas curve B indicates the results obtained when a wafer support of a conventional type having a protrusion at the center thereof was used. From curve B of this graph, it is seen that the film thickness abruptly decreases in the vicinity of the center of wafer W in the conventional wafer support. By contrast, it is seen from curve A that no fluctuation in film thickness is observed even in the vicinity of the center of wafer W in the wafer support of the present invention, whereby an epitaxially grown silicon film having a substantially uniform thickness can be obtained. It is presumed to be because of the fact that, since no protruded part exists under the center of susceptor 22 in accordance with the present invention, the film is grown in a state where the

silicon wafer W is uniformly heated without inhibiting the radiant heat of the halogen lamps 20 from under the process chamber 12.

Though the case where an epitaxial growth apparatus is used as a semiconductor production apparatus is explained in the above-mentioned embodiment, the present invention is not restricted thereby and is applicable to various semiconductor production apparatus such as rapid heat treatment annealing apparatus and thermal CVD apparatus. For example, a uniform film can be obtained in a rapid heat treatment annealing apparatus since temperature becomes constant over the whole surface of wafer.

Though the case where the susceptor support shaft has three arms is explained in the above-mentioned embodiment, four or more arms can be used as well.

Industrial Applicability

An improved wafer support of the present invention comprises a susceptor and a unique susceptor support shaft as explained in the foregoing, whereby the center of susceptor mounting a semiconductor wafer can be heated without inhibiting the radiant heat of a heating source such as halogen lamp from under the process chamber. As

a consequence, it yields an effect that an epitaxially grown silicon film having a uniform thickness is obtained. Also, since the positioning is effected by at least three points by the depressions formed at the peripheral portion in the lower surface of susceptor and the protrusions of arm ends of susceptor support shaft, it yields an effect that more accurate positioning can be carried out.

Further, the whole surface of a semiconductor wafer can be subjected to uniform heat treatment in other heat treatment apparatus as well, since there are no objects in contact with the center portion of semiconductor wafer and, consequently, no heat conduction to the center portion is affected thereby.

As a result, the present invention can respond to higher integration and miniaturization of devices in the field of making electro-micro devices such as semiconductor device.

CLAIMS

1. A semiconductor production apparatus including a process chamber; a wafer support disposed within said process chamber for supporting a semiconductor wafer; and a heating source for heat treatment of the semiconductor wafer supported by said wafer support;

wherein said wafer support comprises a susceptor having an upper surface for mounting said semiconductor wafer thereon, and a susceptor support shaft for supporting said susceptor from thereunder; wherein said susceptor support shaft having a main shaft positioned substantially coaxial with a center of said susceptor, and at least three arms radially extending from an upper end of said main shaft, each said arm having a distal end provided with a protrusion directed toward said susceptor; and wherein a peripheral portion of a lower surface of said susceptor being formed with depressions, each said depression having an inside diameter substantially identical to an outside diameter of said protrusion, adapted to engage said protrusion.

2. A semiconductor production apparatus according to claim 1, wherein said heating source is disposed under said susceptor.

3. A semiconductor production apparatus

according to claim 1 or 2, wherein said depression has an elongated form extending in a radial direction of said susceptor.

4. A semiconductor production apparatus according to claim 3, wherein said protrusion is engaged in said depression on the outermost peripheral side thereof at ambient temperature when said susceptor has a coefficient of thermal expansion greater than that of said susceptor support shaft.

5. A semiconductor production apparatus according to claim 1, wherein said susceptor comprises carbon graphite.

6. A semiconductor production apparatus according to claim 1, wherein said susceptor comprises carbon graphite having a surface coated with silicon carbide.

7. A semiconductor production apparatus according to claim 1, wherein said susceptor comprises silicon carbide.

8. A semiconductor production apparatus according to claim 1, wherein said susceptor support shaft comprises silica glass.

9. A semiconductor production apparatus according to claim 1, wherein said process chamber comprises an inlet for a process gas, and an outlet

for letting out the gas from said process chamber.

10. A semiconductor production apparatus according to claim 9, wherein said process gas is a gas for carrying out an epitaxial growth process.

11. A semiconductor production apparatus according to claim 1, wherein said arm inclines upward as said arm extends radially outward.

ABSTRACT

An epitaxial growth apparatus comprises a process chamber of silica glass, and a wafer support disposed within the chamber. Halogen lamps are disposed below and above the process chamber, and are adapted to heat a semiconductor wafer supported by the wafer support. The wafer support comprises a susceptor for mounting the wafer, and a susceptor support shaft for supporting the susceptor from thereunder. Arms for supporting the susceptor by three points radially extend from the main shaft of the susceptor support shaft. Since the center portion of the lower surface of susceptor has no supporting protrusion, the heat directed toward the center portion of susceptor from the lower halogen lamps is not inhibited, whereby the semiconductor wafer is heated uniformly. Hence, a silicon film having a uniform thickness can be obtained when a normal epitaxial growth process is carried out.

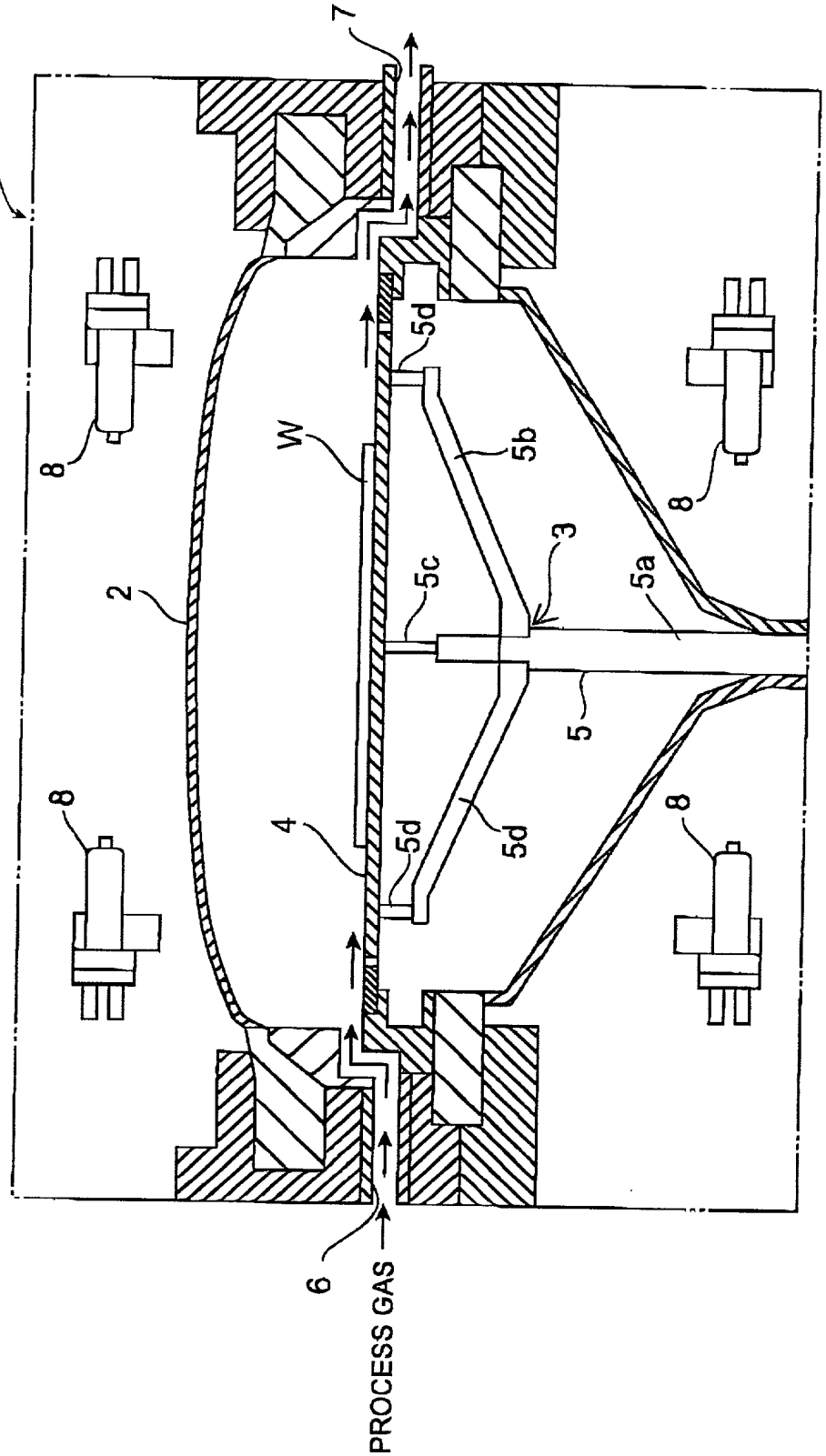


Fig.1

Fig.2

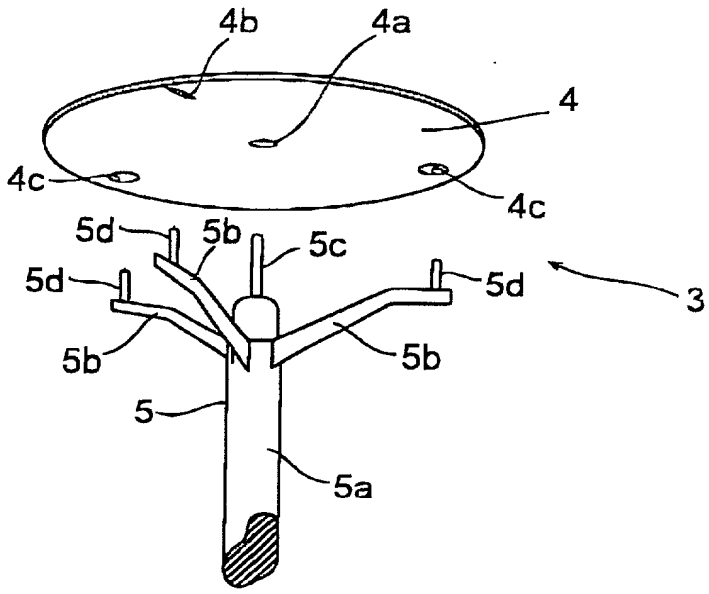
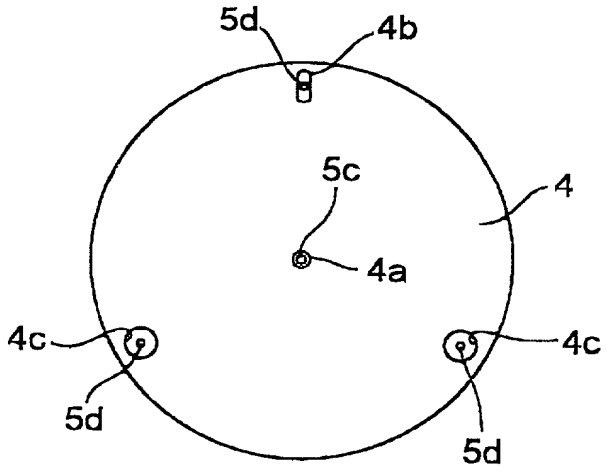


Fig.3



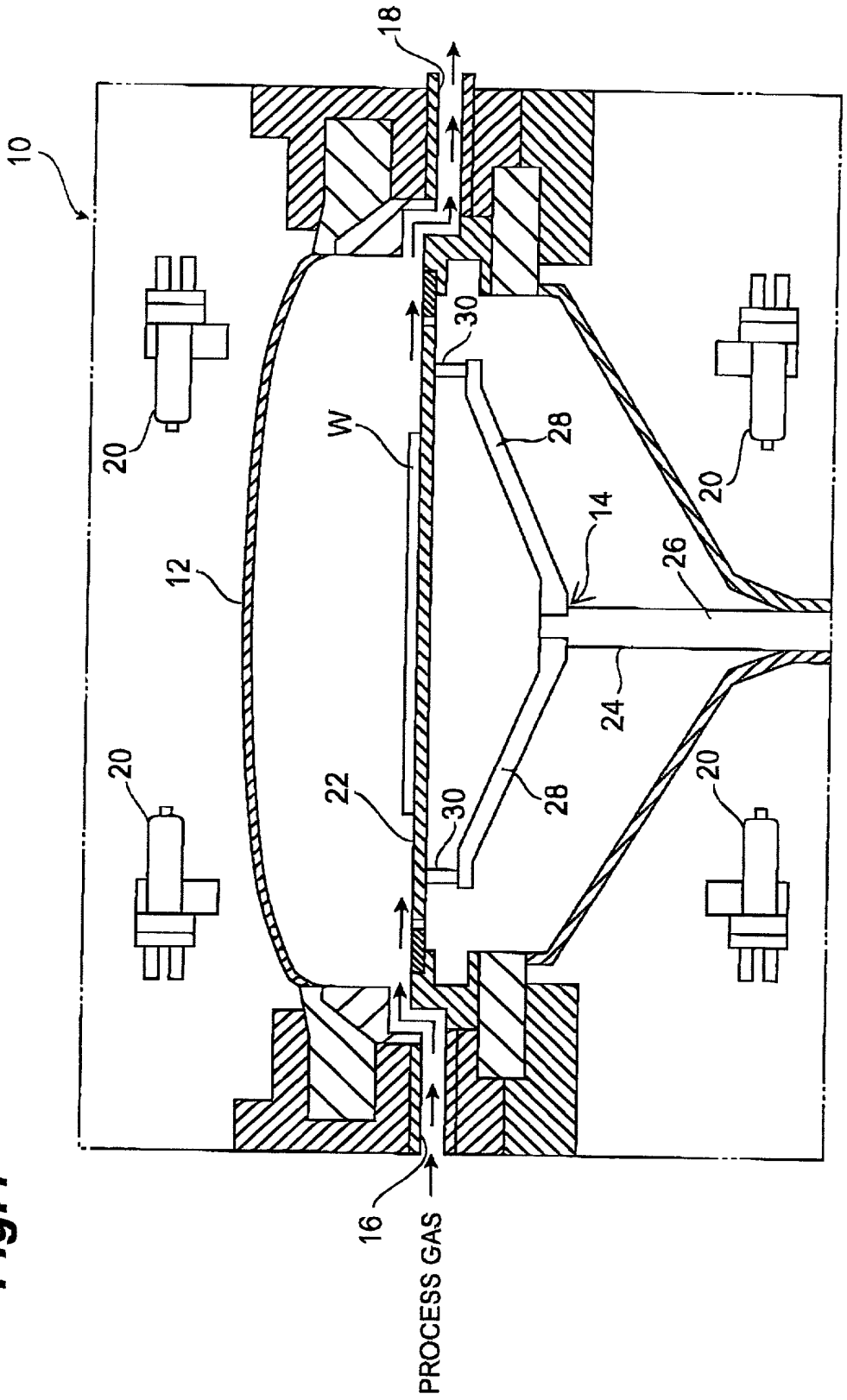


Fig.4

Fig.5

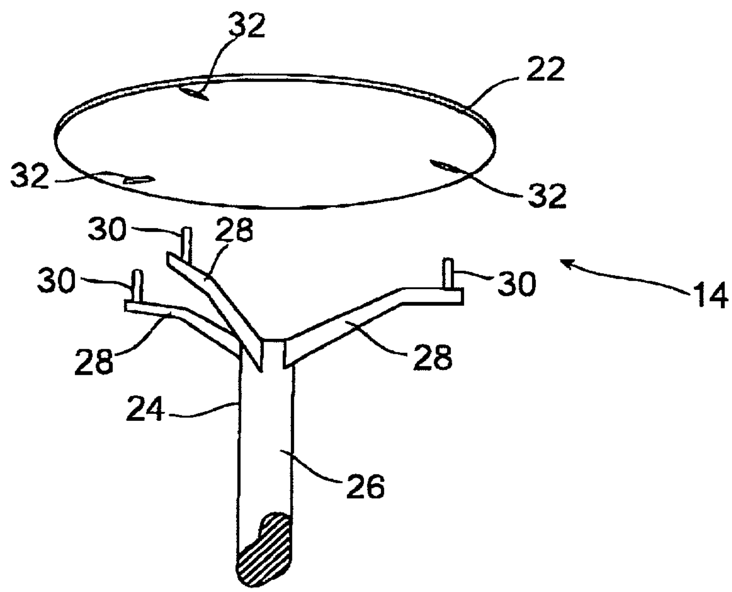


Fig.6

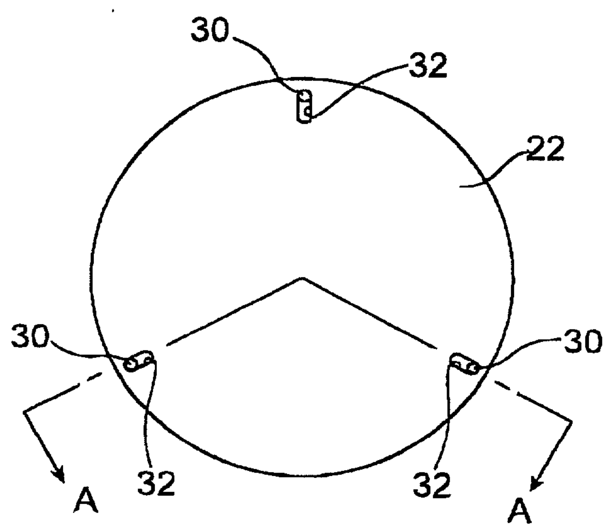
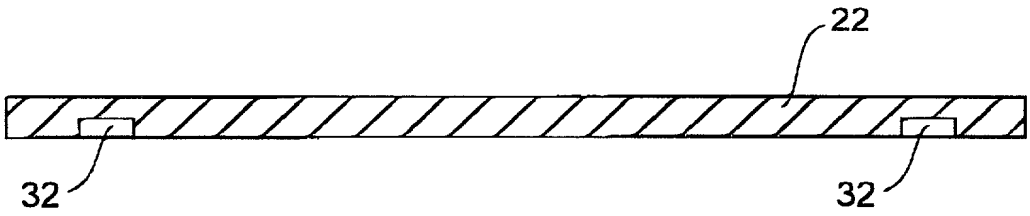


Fig.7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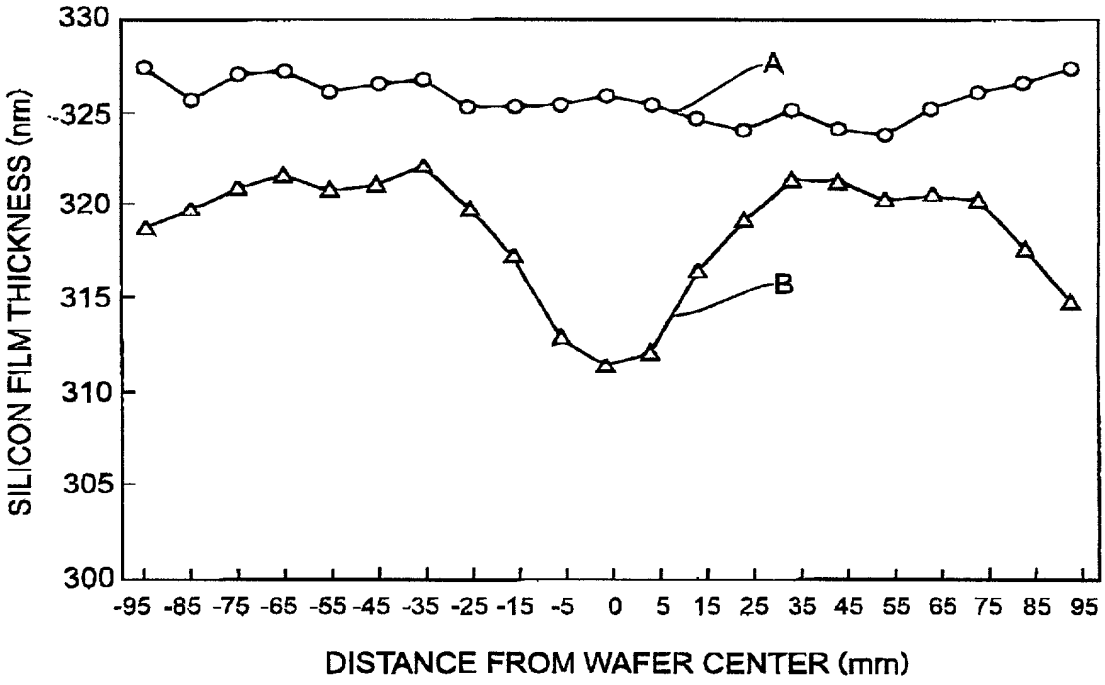
32

Fig.8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SILICON FILM THICKNESS (nm)
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DISTANCE FROM WAFER CENTER (mm)

MCDERMOTT, WILL & EM

Attorney's Docket No. _____

Combined Declaration and Power of Attorney

As a below named inventor, I hereby declare that:

This declaration is of the following type:

[ ] original [ ] supplemental

[X] national stage of PCT
[ ] divisional [ ] continuation [ ] continuation-in-part

My residence, post office address and citizenship are as stated next to my name,

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled
WAFER SUPPORT IN SEMICONDUCTOR PRODUCTION APPARATUS

the specification of which

[ ] is attached hereto.

[ ] was filed on _____
as United States Application Serial Number _____ and,
was amended on _____ (if applicable).

[X] was filed on October 19, 1999
as PCT International Application Number PCT/JP99/05753 and,
was amended under PCT Article 19 on _____ (if applicable).

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

I hereby claim foreign priority under Title 35, United States Code, Section 119(a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or PCT International application having a filing date before that of the application on which priority is claimed.

PRIOR FOREIGN APPLICATIONS, BENEFIT CLAIMED UNDER 35 USC §119(a)

Application Number	Country	Date of Filing (Day/Month/Year)	Priority Claimed Under 35 USC 119
P1998-297087	Japan	19 / October / 1998	[X] Yes [ ] No
			[ ] Yes [ ] No

I hereby claim the benefit under Title 35, United States Code, Section 119(e) of any United States provisional application(s) listed below.

PRIOR U.S. PROVISIONAL APPLICATIONS, BENEFIT CLAIMED UNDER 35 USC §119(e)

(Application No.)	(Filing Date)	(Application No.)	(Filing Date)
(Application No.)	(Filing Date)	(Application No.)	(Filing Date)

I hereby claim the benefit of Title 35, United States Code Section 120 of any United States application(s), or 365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of Title 35, United States Code Section 112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of this application:

PRIOR U.S. APPLICATIONS OR PCT INTERNATIONAL APPLICATIONS DESIGNATING THE U.S., BENEFIT CLAIMED UNDER 35 USC §120

PCT/JP99/05753	October 19, 1999	Pending
(Application No.)	(Filing Date)	(Status: Patented, Pending, Abandoned)
(Application No.)	(Filing Date)	(Status: Patented, Pending, Abandoned)

POWER OF ATTORNEY: As a named inventor, I hereby appoint the registered practitioners of MCDERMOTT, WILL & EMERY included in the Customer Number provided below to prosecute this application and transact all business in the Patent and Trademark Office connected therewith.

Customer Number 20277

Send Correspondence to: Customer Number 20277
MCDERMOTT, WILL & EMERY

600 13TH STREET, N.W.
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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

1-00

Full Name of sole or first inventor Kenichi ARIMURA	
Inventor's signature Kenichi Arimura	Date April 5, 2001
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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

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Docket No.: 50212-211 **PATENT**

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of	:
Kenichi ARIMURA, et al.	:
Serial No.:	: Group Art Unit:
Filed: April 19, 2001	: Examiner:

For: WAFER SUPPORT IN SEMICONDUCTOR PRODUCTION APPARATUS

ASSOCIATE POWER OF ATTORNEY

Honorable Commissioner for Patents and Trademarks
Washington, D. C. 20231

Sir:

The undersigned Principal Attorney of record hereby appoints the following Attorneys as his Associates with regard to the above-identified application: Stephen A. Becker, Reg. No. 26,527; John G. Bisbikis, Reg. No. 37,095; Christopher D. Bright, Reg. No. 46,578; Daniel Bucca, Reg. No. 42,368; Kenneth L. Cage, Reg. No. 26,151; Jennifer Chen, Reg. No. 42,404; Bernard P. Codd, Reg. No. 46,429; Lawrence T. Cullen, Reg. No. 44,489; Paul Devinsky, Reg. No. 28,553; Margaret M. Duncan, Reg. No. 30,879; Shamita De. Etienne-Cummings, Reg. No. 46,072; Ramyar M. Farid, Reg. No. 46,692; Brian E. Ferguson, Reg. No. 36,801; Michael E. Fogarty, Reg. No. 36,139; John R. Fuisz, Reg. No. 37,327; Willem F. Gadiano, Reg. No. 37,136; Keith E. George, Reg. No. 34,111; Matthew V. Grumbling, Reg. No. 44,427; John A. Hankins, Reg. No. 32,029; Joseph Hyosuk Kim, Reg. No. 41,425; Eric J. Kraus, Reg. No. 36,190; Catherine Krupka, Reg. No. 46,227; Jack Q. Lever, Reg. No. 28,149; Raphael V. Lupo, Reg. No. 28,363; Michael A. Messina, Reg. No. 33,424; Dawn L. Palmer, Reg. No. 41,238; Joseph H. Paquin, Jr., Reg. No. 31,647; Scott D. Paul, Reg. No. 42,984; William D. Pegg, Reg. No. 42,988; Robert L. Price, Reg. No. 22,685; Gene Z. Rubinson, Reg. No. 33,351; Joy Ann G. Serauskas, Reg. No. 27,952; Daniel H. Sherr, Reg. No. 46,425; David A. Spenard, Reg. No. 37,449; Arthur J. Steiner, Reg. No. 26,106; David L. Stewart, Reg. No. 37,578; Wesley Strickland, Reg. No. 44,363; Michael D. Switzer, Reg. No. 39,552; Daniel S. Trainor, Reg. No. 43,959; Cameron K. Weiffenbach, Reg. No. 44,488; Aaron Weisstuch, Reg. No. 41,557; Edward J. Wise, Reg. No. 34,523; Jeffrey A. Woller, Reg. No. 48,041; Alexander V. Yampolsky, Reg. No. 36,324; and Robert W. Zelnick, Reg. No. 36,976 all of

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